NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594

February 3, 2012

FACTUAL REPORT OF POWERPLANTS GROUP CHAIRMAN

NTSB ID: DCA12MA020

A. ACCIDENT

Location:	14 miles east of Las Vegas, Nevada
Date:	December 7, 2011
Time:	1630 pacific standard time (PST)
Aircraft:	Eurocopter AS-350-B2, S/N 2300, Reg. No. N37SH, Sundance Helicopters, Inc.

B. POWERPLANTS GROUP

Chairman:	Carol M. Horgan National Transportation Safety Board Washington, DC
Member:	Alan M. McKinney Federal Aviation Administration Las Vegas, Nevada
Member:	Bryan P. Larimore Turbomeca Engine Corporation Grand Prairie, Texas

C. SUMMARY

On December 7, 2011 at 1630 PST, a Eurocopter AS 350B2, registration N37SH, operated by Sundance Helicopters as flight Landmark 57, crashed in mountainous terrain approximately 14 miles east of Las Vegas, Nevada. The 49 CFR Part 135 flight was a tourist sightseeing flight, which departed from Las Vegas McCarren International Airport (LAS), Las Vegas, NV, intending to fly to the Hoover Dam area and return to LAS, operating under visual flight rules. The helicopter impacted in a ravine in mountainous terrain between the city of Henderson and Lake Mead. The pilot and four passengers were fatally injured, and the helicopter was substantially damaged by impact forces and fire. Access to the accident site was moderately difficult and the investigators were assisted by the National Park

Service. There were no installed on-board recording devices. Weather was reported as clear with good visibility and dusk light conditions.

Radar data obtained from the FAA show that the helicopter departed LAS and followed a normal route of flight easterly out of the LAS airport traffic area, then turned to the southeast toward the Hoover Dam. Tour routings are standardized for all the area tour operators. The helicopter was level at 3,500 feet at approximately 120 knots. About one minute prior to the accident, the radar indicated that the helicopter climbed to 4,100 feet and turned about 90 degrees to the left. The left turn and climb are not part of the normal route. Radar then indicated that the helicopter descended to 3,300 feet and tracked a northeasterly course for about 20 seconds, until entering a left turn, then a descent of at least 2,500 feet per minute. The last radar target received was about 1/8 mile from the accident site.

The helicopter was powered by a Turbomeca Arriel 1D1 turboshaft engine. A Powerplants Group was formed on December 8, 2012 at Henderson, Nevada. Members of the group documented the engine on site, December 8-11, 2011.

D. DETAILS OF THE INVESTIGATION

1.0 Engine information

1.1 Engine description

The Turbomeca Arriel 1D1 is a free turbine, fixed geometry turboshaft engine rated at 732 shaft horsepower (takeoff). The gas generator consists of a one-stage axial, one-stage centrifugal compressor, an annular combustor with centrifugal fuel injection, and a two-stage gas generator turbine. The rotational speed of the gas generator (Ng) is determined by the rate at which fuel is burned in the combustor. Gas generator exhaust gases drive a single-stage power turbine, which drives a reduction gear assembly (RGB). Torque is transferred forward[1] through a power shaft to an accessory gearbox (AGB) and power takeoff at the front of the engine. The gas generator rotates counter-clockwise; and the power turbine (Ntl) and output pinion of the reduction gear rotate clockwise. The engine is modular, and both Ng and Ntl cycles are tracked.

1.2 Engine data

The engine was a Turbomeca Arriel 1D1, part number (P/N) 0292005220, serial number (S/N) 9043. The engine modules are identified in Table 1.

module	*component*	*P/N*	*S/N*
N/A	engine	0292005220	9043
M01	AGB and power shaft	70BMO15420	9043
M02	axial compressor	70BMO25020	2835
M03	gas generator	70BMO35420	9778
M04	free turbine	70BMO45400	9226
M05	RGB	70BMO55420	9509

Table 1. Engine S/N 9043 module data

[1] All references to position are aft looking forward unless otherwise noted.

1.3 Engine service history

A review of the N37SH maintenance records found that engine S/N 9043 was a rental unit provided by Vector Aerospace, Richmond, British Columbia, Canada. It was installed onto N37SH on December 6, 2011, due to an engine removal for scheduled maintenance. A maintenance operational check flight was performed on December 6, 2011, with no engine anomalies noted. See Attachment 1.

A review of the engine maintenance records for the past 10 years found only routine rental engine maintenance activity. Modules 02, 03, and 04 were overhauled and module 01 was repaired and received a 3,000 hour inspection at Acro Helipro Global Services, Inc, Vancouver, Canada, in February 2008. In March 2011, module 05 was repaired, and Service Bulletin 292720832 was embodied to extend the time between overhauls for modules 02, 03, 04 and 05. At the time of the accident, the engine had accumulated approximately 7,403.5 hours, 9,673.2 Ng cycles, and 7,851.3 Ntl cycles.[2]

2.0 On site investigation

The aircraft fuel cell was fragmented, and much of the aircraft, including the tailboom and cabin, was consumed by fire. See Figure 1.

Figure 1. Aircraft wreckage

[2] The engine time and cycle counts include an estimated 3.5 flight hours and 6.0 flight cycles reported by Sundance Helicopter as flown by the helicopter on the day of the accident.

The engine was found in an upright position, near the main rotor head. See Figure 2.

Figure 2. Engine in debris field

2.1 Engine inspection

2.1.1 Engine external inspection

The engine data plate confirmed the engine model and serial number on record. The engine showed no evidence of in-flight fire. There was sooting on the axial compressor and thermal damage to external accessories, consistent with post-impact fire. The fuel control unit (FCU), the starter-generator, and the oil check valve were separated from the engine. There was severe thermal damage to the fuel inlet supply line, the engine wiring harness, the gas generator rear bearing chip detector, and the oil check valve. Metallic debris had collected at the bleed valve screen. See Figure 3. The location and appearance of the debris was consistent with material having been ingested by the engine during operation. The bleed valve screen was removed, and oil and debris similar to the debris noted at the bleed valve screen coated the inside of the valve housing.

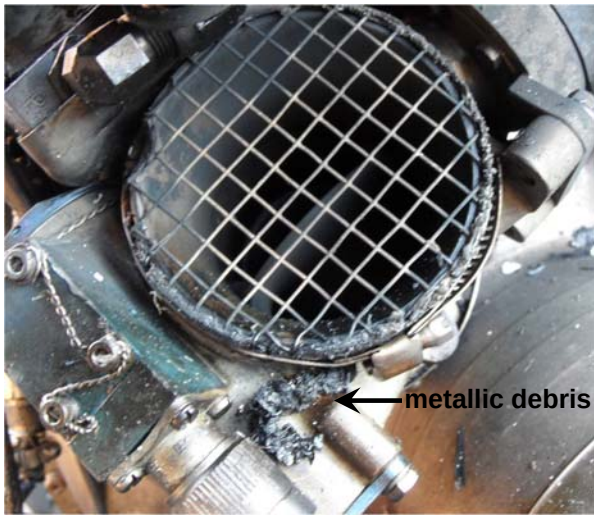

Figure 3. Debris buildup at the bleed valve outlet

2.1.2 Engine inlet

The axial compressor casing was deformed inwardly at 11 and 5 o'clock.[3] See Figure 4. All of the axial compressor blades were battered and the blade tips were missing material; many of the blade tips were broken off. [4] The remaining blade tip material was curled opposite to the direction of rotation. The casing deformation and blade tip breakage/curling were consistent with the compressor experiencing severe radial loading during engine operation. The battered condition of the axial compressor was consistent with the ingestion of objects into the engine inlet during operation. The compressor nose cone was heat damaged and exhibited scoring consistent with contact by a hard object while the engine was operating. The FCU was found separated from the engine and the FCU-to-overspeed and drain valve tube was fractured at the FCU end. The tube was deformed and a flattened area near the separated end of the tube was positioned close to the nose cone.

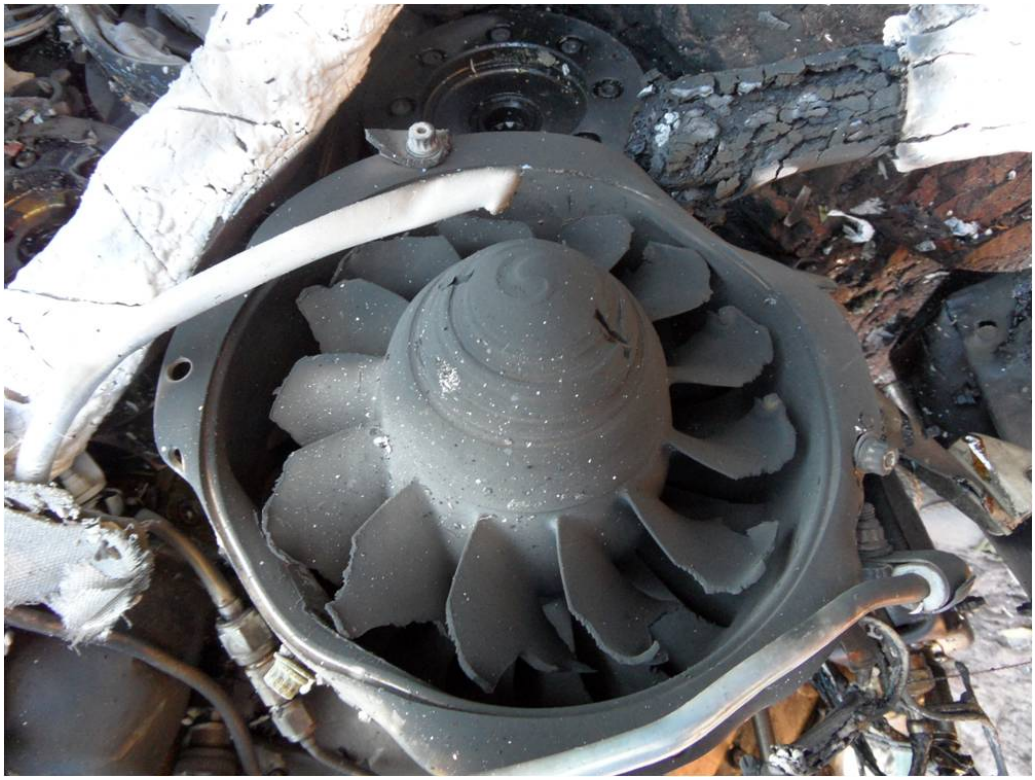

Figure 4. Engine inlet showing deformed compressor casing, severely damaged compressor axial stage, and circumferentially scored nose cone

2.1.3 Engine exhaust

A segment of the power turbine (PT) was visible through the exhaust pipe, and was accessible by hand. See Figure 5. A tactile inspection of the rotor determined that all of the PT airfoils were intact, and that the rotor turned freely.

[3] O'clock refers to approximate circumferential locations in a clockwise direction, viewed from the rear of the engine looking forward.

[4] The axial compressor rotor is a titanium alloy forging.

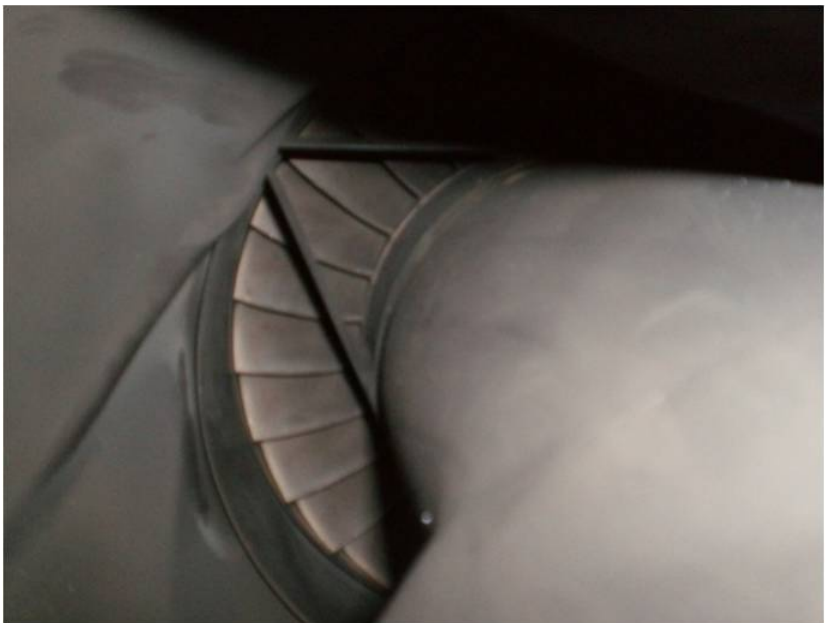

Figure 5. Power turbine viewed through exhaust

2.1.4 Engine shafts and couplings

The freewheel unit had broken away at the power takeoff flange. The power takeoff flange was distorted, and two of the flange attachment bolts were sheared; the other bolt was not recovered. The freewheel shaft was separated. See Figure 6. The tail rotor drive coupling was cracked and distorted, and the flexible disks were splayed and broken. See Figure 7.

Figure 6. Power takeoff flange and aft fracture surface of freewheel shaft

Figure 7. Tail rotor drive flange coupling damage

The engine and freewheel unit/helicopter main gearbox driveshaft and housing were removed from the debris field. The engine casings showed no evidence of uncontainment. See Figures 8 – 12.

Figure 8. Engine S/N 9043, left side view

Figure 9. Engine S/N9043, right side view

The freewheel clutch was rotated, and it turned freely in the drive direction, and did not turn in the opposite direction, verifying its operation.

Figure 10. Freewheel unit with forward section of freewheel shaft in helicopter main gearbox drive shaft housing

Accessory gearbox Ng gear train continuity was confirmed from both the FCU Ng drive pad and the Ng shaft to the starter drive pad. Accessory gearbox Ntl gear train continuity was confirmed from the power drive to the Ntl FCU drive pad. See Figure 11.

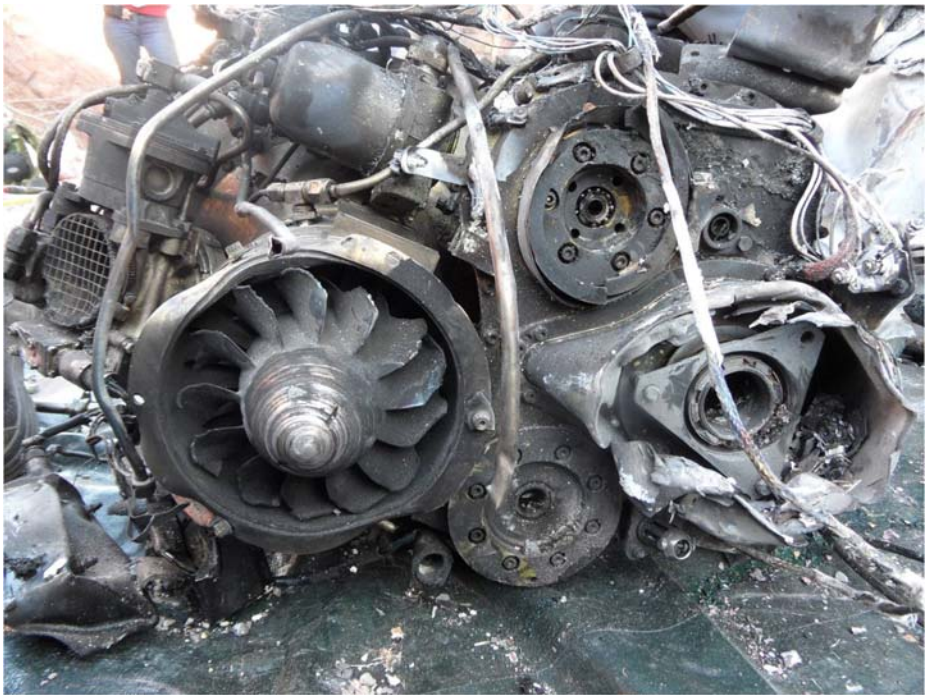

Figure 11. Engine S/N 9043 - front view

Figure 12. Engine S/N 9043 – back view

Two of the four bolts that attach the accessory gearbox to the axial compressor were sheared.

2.2 Analytical engine disassembly

The engine was partially disassembled on site. The FCU fuel filter element was inspected and found clean. See Figure 14.

The oil filter was removed and was found clean. See Figure 15. The magnetic plugs were removed and inspected. Metal shavings and a single steel ball were found on the M01 module magnetic plug tip. The ball was consistent with the FCU drive bearing elements, several of which were missing. Metal shavings were found on the tip of the M05 magnetic plug. The two electric chip detectors were thermally damaged, with no relevant findings.

The reduction gearbox was removed, exposing the muff coupling, See Figure 16. The muff coupling is a 1 3/8-inch long internally-splined coupling that transfers the driving

Figure 14. Fuel filter element

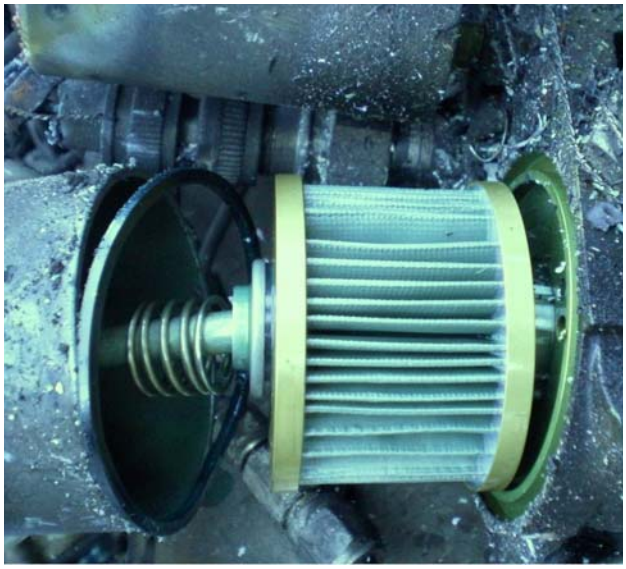

Figure 15. Oil filter element

torque from the power turbine (module 04) to the reduction gear train input pinion (module 05). A 7/8-inch steel insert provides the stop for the respective shafts. The outside surface coating of the coupling showed shiny circumferential marks. There was a pattern of deep nicks on the trailing sides of the module 04 coupling splines, progressing from light to severe, and the forward faces of the four tabs on the module 04 side of the insert appeared

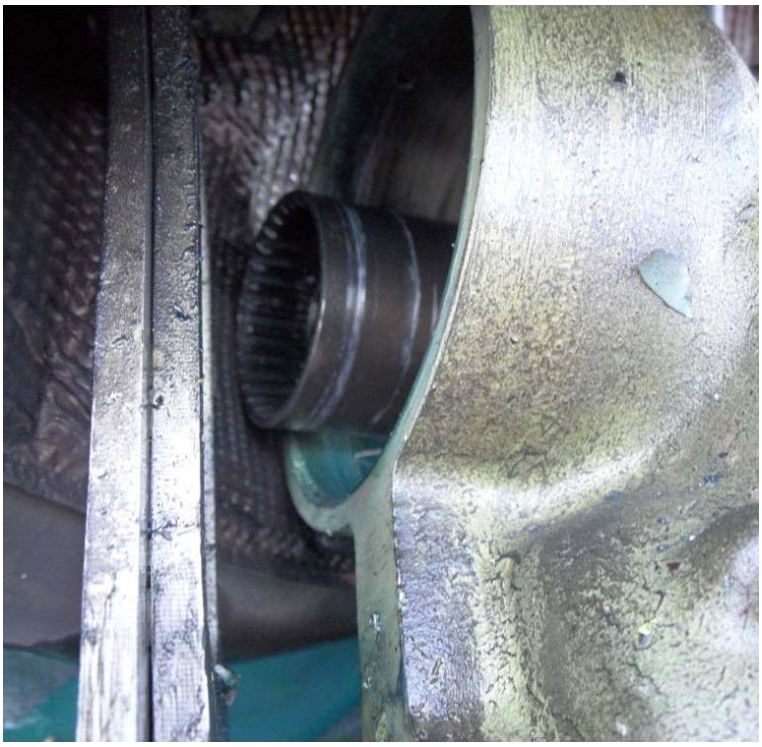

Figure 16. Muff coupling exposed

compressed and showed light scoring in the circumferential direction. See Figure 17. The beveled ends of the splines on the module 05 side of the coupling were roughened.

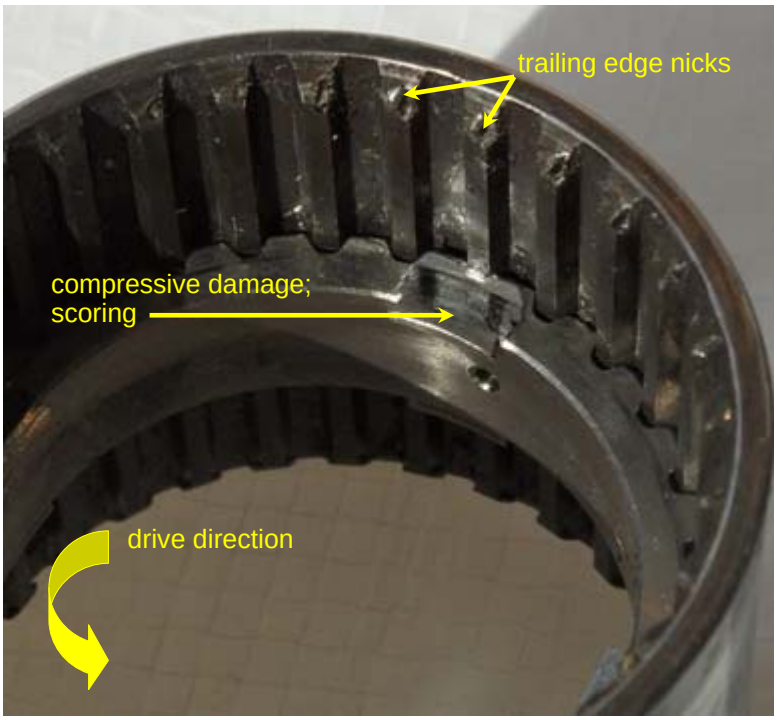

Figure 17. Muff coupling, showing damage on the drive sides of the driven splines and at tabs

Arriel engine manual assembly instructions for the reduction gearbox require an alignment mark to be made across the left-threaded input pinion nut and the pinion shaft after assembly torque is applied.[5] The alignment mark is used as a visual check following a rotor strike, over torque, or overspeed incident. The measured angular distance between marks represents nut over-tightening in the drive direction and serves as an estimate of the force load on the reduction gears.[6]

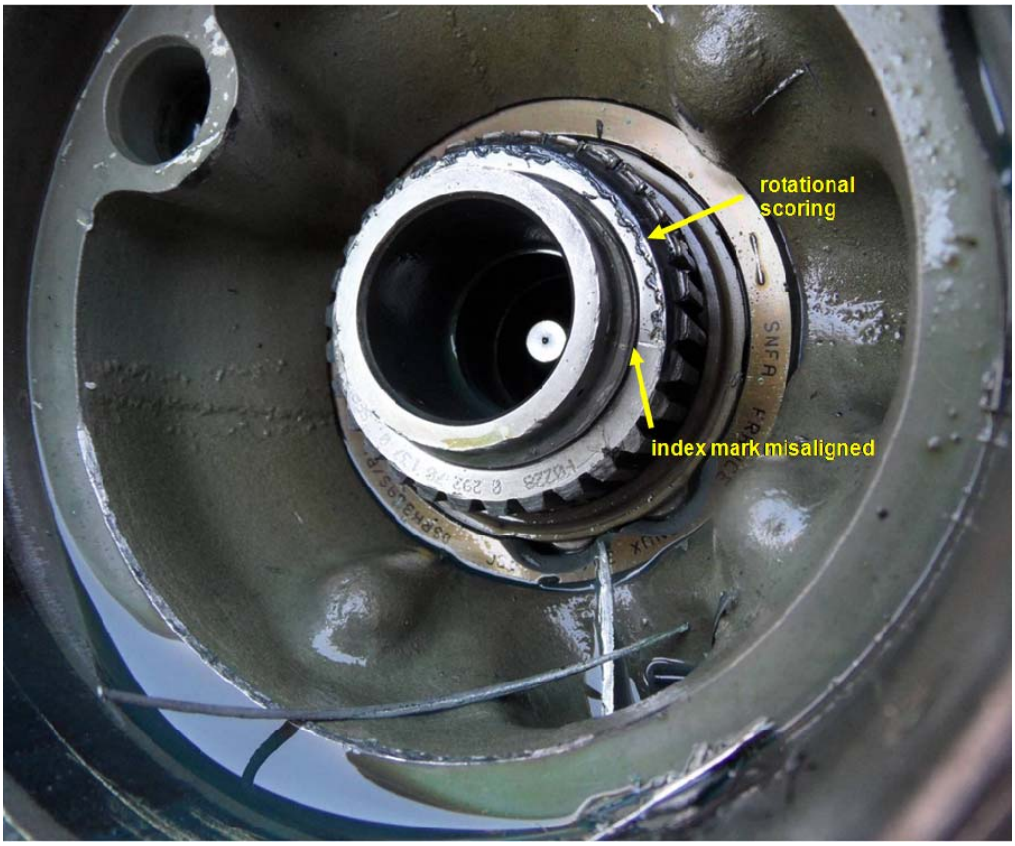

Figure 18. Input pinion nut showing assembly index mark misalignment in the driving direction

Examination of the pinion assembly found that the input pinion nut index mark was misaligned approximately 1 mm past the input shaft index mark, in the driving direction. See Figure 18. According to Turbomeca, 1 mm displacement indicates that just over 25 daNm, or 184.4 ft lbs, of force was applied to the drive pinion nut. The torque applied at the input pinion nut during operation at takeoff power is 11 daNm, or 81.13 ft. lbs.

Reduction gear train continuity was confirmed from the input pinion to the output pinion. See Figure 19.

[5] Turbomeca Arriel 1 D1 Maintenance Manual, 71-02-05-280-801-A01, Page 201, June 30, 2009

[6] Turbomeca Arriel 1 Overhaul Manual, Driving Pinion Assembly, 72-15-00-43H-801-A01, Page 1001, November 30, 2009

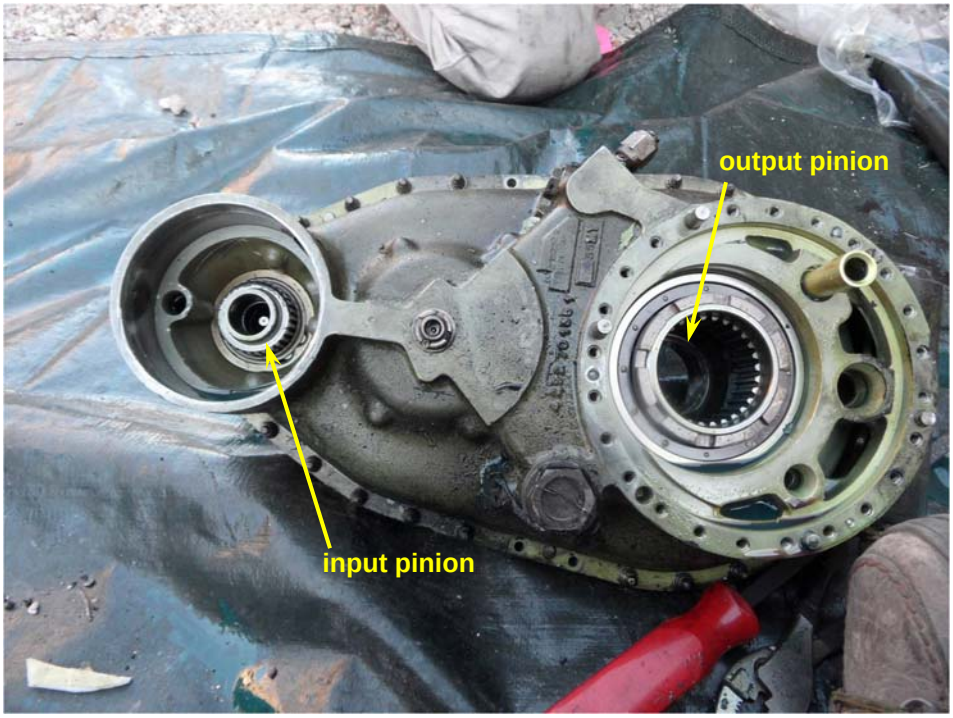

Figure 19. Reduction gearbox

E. ATTACHMENT

1. Engine Data Excerpt from Sundance Helicopters N37SH Aircraft Maintenance Status Sheet